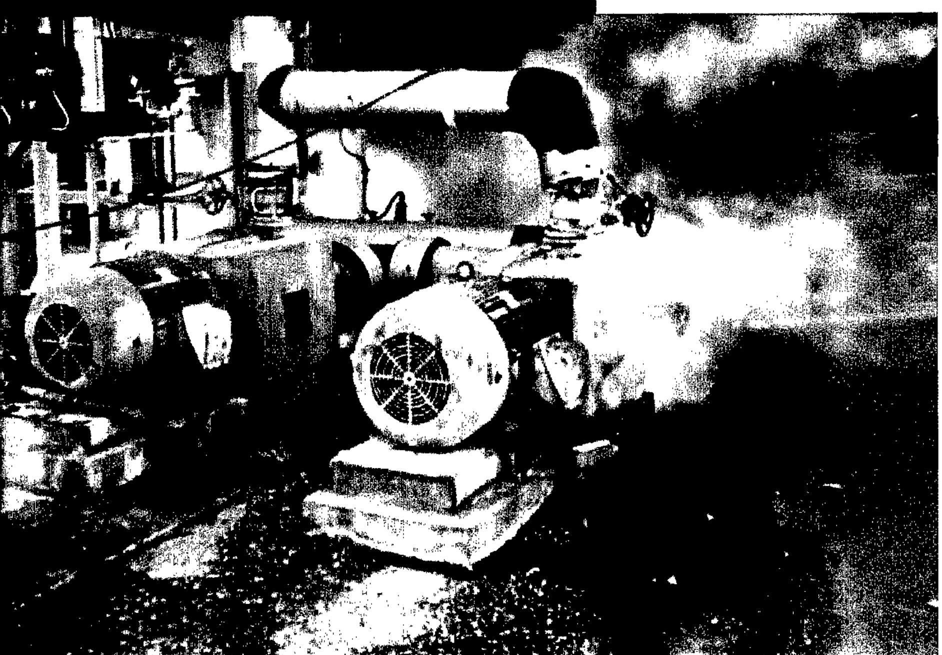
Volume ES
Executive Summary

# Combined Limited Energy Study of Electrical Energy Demand and Usage and Heating Systems Pine Bluff Arsenal, Arkansas



Contract #DACA01-94-D-0038/0004
Project #694-1331-004



RS&H

Reynolds, Smith and Hills, Inc.
*Architectural, Engineering, Planning and Environmental Services*

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# A COMBINED LIMITED ENERGY STUDY OF ELECTRICAL ENERGY DEMAND AND USE AND HEATING SYSTEMS AT PINE BLUFF ARSENAL, ARKANSAS

## VOLUME ES
## EXECUTIVE SUMMARY

## FINAL SUBMITTAL

Prepared for
U. S. Army Engineer District, Little Rock

Contract Number DACA01-94-D-0038
Delivery Order Number 0004

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September 1996



694-1331-004

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# 1.0 INTRODUCTION

## 1.1 AUTHORIZATION

Architectural-engineering services for the Energy Engineering Analysis Program (EEAP) - Southeast Region were authorized by the US Army Corps of Engineers, Mobile District Contracting Division under Indefinite Delivery Contract Number DACA01-94-D-0038. Engineering services for the Combined Limited Energy Study of Electrical Energy Demand and Usage and Heating Systems at Pine Bluff Arsenal (PBA) were authorized by Delivery Order Number 4 from the US Army Engineer District, Little Rock. Reynolds, Smith and Hills, Inc. (RS&H) received the Notice to Proceed for Delivery Order Number 4 on September 12, 1995.

## 1.2 OBJECTIVES

The primary purpose of this contract is to conduct a detailed study of the boilers, air compressors and large electric motors in the production areas of PBA and develop projects to improve the efficiency of these systems. This study includes comprehensive field investigations of the boiler and compressed air plants; boiler efficiency testing; survey and analysis of the steam distribution system; measurement of electric motor power consumption; identification of Energy Conservation Opportunities (ECO's); energy and labor savings calculations; cost estimates and economic analysis of the ECO's.

## 1.3 WORK ACCOMPLISHED

The entry interview was conducted at the PBA Department of Public Works (DPW) office on January 29, 1996. RS&H conducted two field investigations to obtain the data required to analyze all of the boiler, compressor and electric motor ECO's. The initial field investigation, personnel interviews and data collection was performed at PBA from January 29, 1996 through February 1, 1996. The second field investigation was performed during the week of March 26 - 29, 1996. Information obtained during these site visits indicated that an enormous amount of energy was being wasted from leaks in the steam distribution system.

Consequently, a no-cost modification to the Scope of Work was requested and approved to include investigation and analysis of a project to repair or replace the existing steam piping distribution system. A subsequent field investigation was performed May 13 - 17, 1996 to survey the steam distribution system serving the production facilities located in Section 3, Areas 1, 2, 3 and 4.

Energy and labor savings calculations, cost estimates and economic analyses were completed for all of the ECO's. All Interim Submittal Review Comments were resolved and the results were used to

finalize all sections of the Final Submittal for this study. This submittal includes the following volumes:

- Volume ES; an executive summary that gives a brief overview of the results of this study.
- Volume I; a narrative report containing the methodology for field investigations and data analysis, ECO project evaluations, results of the evaluations, and recommendations for improvements in the heating system, the steam distribution system, the compressed air system and large electric motors at PBA.
- Volume II; appendices with ECO calculations, cost estimates, back-up data, a copy of the Scope of Work.
- Volume III; appendices containing copies of the field investigation forms.
- Volume IV; programming documentation for all recommended ECO's and combination of ECO's, based on direction provided by PBA.

## 2.0 BUILDING / SYSTEMS DATA

### 2.1 GENERAL DESCRIPTION

Pine Bluff Arsenal (PBA) covers about 14,900 acres and is located approximately 35 miles southeast of Little Rock, Arkansas. PBA is a government-owned, government-operated (GOGO) installation established in 1941 to produce incendiary munitions. The Arsenal's mission now includes the design, manufacture, renovation, and demilitarization of signaling and screening smoke, riot control agents, incendiary munitions and chemical/biological defensive items. PBA also provides support for training operations for active and reserve military units.

There are five main functions within the arsenal: production, incineration, water treatment, bomb storage and administrative/housing. The scope of work for this project includes the boilers and electric motor-operated equipment associated with the production, incineration and water treatment processes. Figure 2.1-1 shows a partial schematic site plan showing the production areas of PBA.

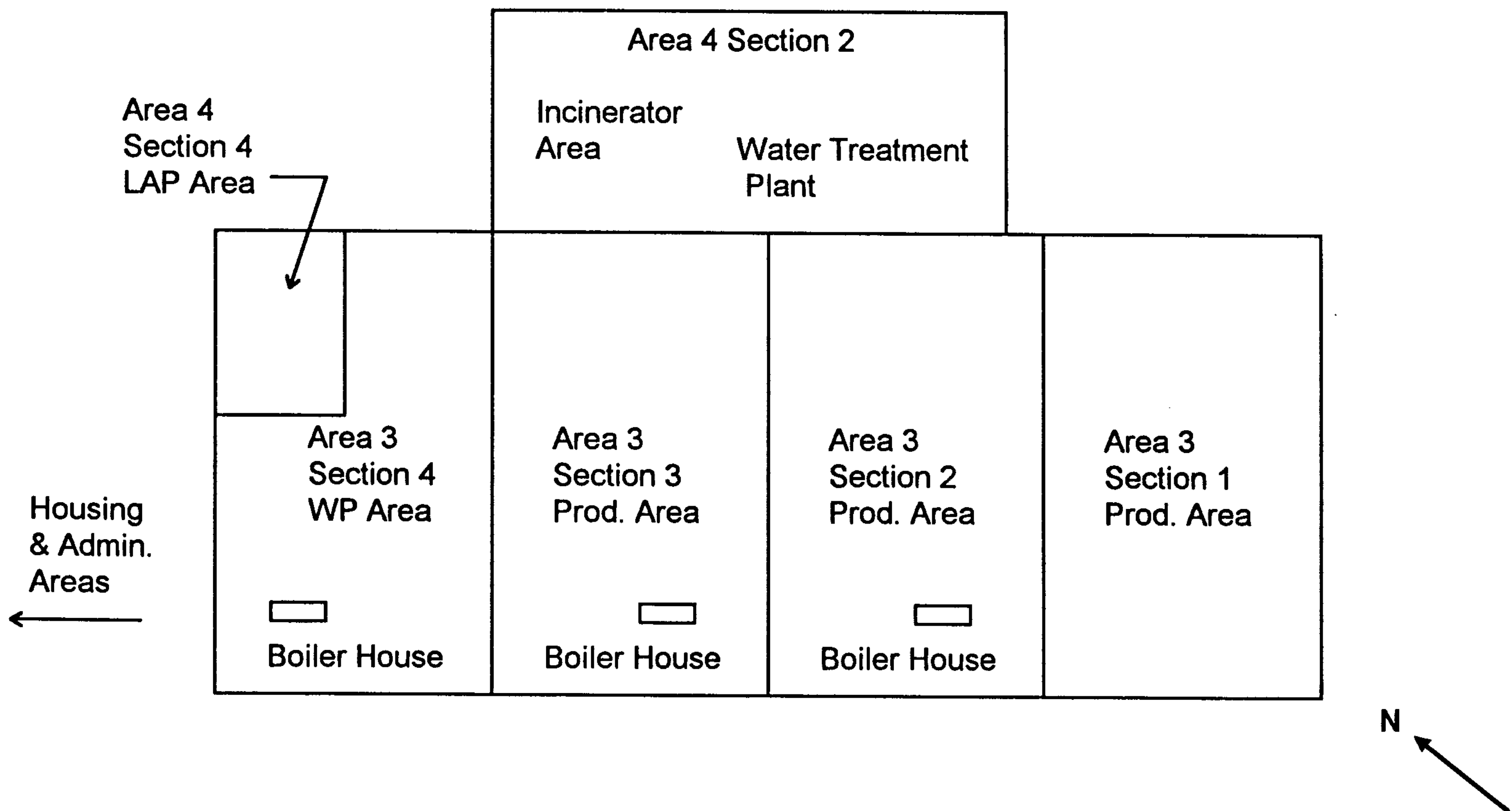
### 2.2 BOILERS

There are five boiler houses that provide steam to the various production areas. The steam is utilized for space (comfort) heating, process heating and process humidification. The boilers in Buildings 32-060, 33-060 and 34-140 are connected through a manifold and provide steam to Areas 31, 32, 33, and 34. The boilers in Building 42-960 serve Area 42 (the incinerator area) and the boilers in Building 44-120 provide steam to Area 44 (LAP area). The following table provides a summary of the boilers surveyed.

| Boiler Data | | | | | | |
|---|---|---|---|---|---|---|
| Building Number | Boiler No. | Fuel Used | Rated Capacity | Boiler Manufacturer(s) | Year Installed | Avg. Eff. Measured |
| 32-060 (1) | 1 | N. Gas | 311 HP | Babcock & Wilcox | 1942 | 74-75% |
| | 2 | N. Gas | 311 HP | Babcock & Wilcox | 1942 | 74-75% |
| 33-060 | 1 | N. Gas | 311 HP | Babcock & Wilcox | 1942 | 74-75% |
| | 2 | N. Gas | 311 HP | Babcock & Wilcox | 1942 | 74-75% |
| 34-140 (2,3) | 1 | N. Gas | 249 HP | Babcock & Wilcox | 1942 | 72% |
| | 2 | N. Gas | 249 HP | Babcock & Wilcox | 1942 | NA |
| | 3 | N. Gas | 249 HP | Babcock & Wilcox | 1942 | 72% |
| 42-960 | 1 | N. Gas | 40 HP | Aztec Superior | 1978 | 79% |
| | 2 | N. Gas | 40 HP | Aztec Superior | 1978 | 79% |
| 44-120 | 1 | N. Gas | 100 HP | Ray Burner | 1969 | NA |
| | 2 | N. Gas | 100 HP | Cleaver Brooks | 1989 | 83% |

(1) The Arsenal has two new boilers on site that have not been installed. These boilers are rated at 600 horsepower each. PBA plans to remove the two existing boilers located in Building 32-060 and install the new boilers in the near future.

**Figure 2.1-1**
**Pine Bluff Arsenal Partial Schematic Site Plan**



(2) There is no deaerator for the boilers in this building. There is an Energy Conservation Investment Program (ECIP) project pending to construct a new boiler facility in Area 3, Section 4. The new facility will contain two boilers rated at 350 horsepower each. The existing boilers in Building 34-140 will be phased out of service and demolished.

(3) Boiler Number 2 is not operational due to a leak in the flue breaching stack.

## 2.3 STEAM DISTRIBUTION SYSTEM

The production facilities in Areas 31, 32, 33, and 34 utilize steam from a main distribution system. The boilers in Buildings 32-060, 33-060 and 34-140 are connected by about two miles of manifold pipe (the "high line") and provide steam to each of these areas via sets of branch pipes. The main steam header is called the "high line" because it is mounted approximately 30 feet above ground on wooden utility poles. The branch distribution piping is typically mounted about two feet above ground level. When the pipes cross a road, they are raised to approximately 15 feet. There is a total of approximately eight miles of steam distribution piping serving the production facilities in Areas 31, 32, 33, and 34, including the main header piping.

## 2.4 AIR COMPRESSORS

The production facilities in Areas 31, 32, 33, and 34 utilize compressed air from a main distribution system. Buildings 32-060, 33-060 and 34-140 each contain two air compressors that supply the main distribution system. Process air for the incinerator operations is provided by a new compressor located in Building 42-961. This unit was installed to replace the air compressor located in Building 42-960. A summary of the air compressors surveyed is presented in the following table.

| Air Compressor Data | | | | | | |
|---|---|---|---|---|---|---|
| Building Number | Compressor No. | Motor HP | Motor Type | Rated Capacity | Compressor Manufacturer(s) | Year Installed |
| 32-060 | 1 | 150 | Synchronous | 825 CFM | Ingersoll-Rand | 1967 |
| | 2 | 173 | Synchronous | 825 CFM | Ingersoll-Rand | 1967 |
| 33-060 | 1 | 173 | Synchronous | 825 CFM | Ingersoll-Rand | 1967 |
| | 2 | 173 | Synchronous | 825 CFM | Ingersoll-Rand | 1967 |
| 34-140 | 3 | 150 | Synchronous | 825 CFM | Ingersoll-Rand | 1967 |
| | 4 | 173 | Synchronous | 825 CFM | Ingersoll-Rand | 1967 |
| 42-961 | 1 | 75 | Induction | NA | Sull-Air | 1993 |

## 2.5 ELECTRIC MOTORS

The following table provides a summary of the electric motors surveyed.

| Electric Motor Data | | | | | |
|---|---|---|---|---|---|
| Building Number | Motor Use | Motor HP | Motor Type | Motor Manufacturer | Electric Volts/Ph/Hz |
| 32-060 | Compressor No. 1 | 150 | Synchronous | General Electric | 460/3/60 |
| | Compressor No. 2 | 150 | Synchronous | General Electric | 460/3/60 |
| 33-060 | Compressor No. 1 | 150 | Synchronous | General Electric | 460/3/60 |
| | Compressor No. 2 | 150 | Synchronous | General Electric | 460/3/60 |
| 34-140 | Compressor No. 3 | 150 | Synchronous | General Electric | 460/3/60 |
| | Compressor No. 4 | 173 | Synchronous | General Electric | 460/3/60 |
| 34-196 | Scrubber Fan | 800 | Induction | Louis-Allis | 2300/3/60 |
| | Scrubber Fan | 800 | Induction | Louis-Allis | 2300/3/60 |
| 42-010 | Pump | 150 | Induction | U.S. Electric Motor | 440/3/60 |
| 42-020 | Pump | 150 | Induction | U.S. Electric Motor | 460/3/60 |
| 42-030 | Pump | 150 | Induction | NA | 440/3/60 |
| 42-210 | Pump No. 1 | 30 | Induction | Sterling Motor | 440/3/60 |
| | Pump No. 2 | 30 | Induction | NA | 440/3/60 |
| | Pump No. 3 | 30 | Induction | NA | 440/3/60 |
| | Pump No. 4 | 30 | Induction | NA | 440/3/60 |
| 42-979 | Scrubber Fan | 350 | Induction | TECO | 460/3/60 |

# 3.0 PRESENT ENERGY CONSUMPTION

## 3.1 HISTORICAL ENERGY USE AND COST

The primary energy sources utilized at PBA are natural gas and electricity. Natural gas is provided by a government contract with Falling Tree Enterprises located in Tulsa, Oklahoma, and is supplied to the Arsenal through a single-metered supply line. The monthly readings from the main meter are the basis for determining the total monthly natural gas consumption at PBA and the monthly billing by the natural gas supplier. The natural gas is then distributed to approximately 75 buildings within the Arsenal.

Electricity is provided by the Arkansas Power & Light Company (AP&L). There are three electric substations that provide electric service to PBA. Substation A serves incinerator, water plant and LAP facilities (Areas 42 and 44), Substation B serves the production facilities (Areas 31,32, 33 and 34) and Substation C serves the administration and housing areas of the Arsenal. PBA receives two electric bills each month, one for Substations A and B combined and one for Substation C. The facilities served by Substations A and B use approximately 70 percent of the total electricity consumed at PBA. The Scope of Work for this project is confined to the production areas, so only the electric energy use for Substations A and B will be considered in this report.

The monthly consumption of natural gas and electricity at PBA is presented in Figure 3.1-1. This figure shows there is a natural gas base load of about 35,000 million British thermal units (MBtu) per month during the summer. This base load is mostly due to steam leaks and process energy requirements. Natural gas consumption increases to over 83,000 MBtu per month during the winter because of space heating requirements.

Electricity use in the production areas at PBA is much lower than natural gas use. Figure 3.1-1 indicates the facilities served by Substations A & B have an electric base load of approximately 3,600 MBtu per month during the winter. Their consumption rises to about 6,500 MBtu per month during the summer due to space cooling requirements. The primary components of the electric base load are compressor motors, fan and pump motors for the incinerator and water plant pump motors.

Figure 3.1-2 shows natural gas is by far the main energy source for the Arsenal. The natural gas energy consumption is broken down by end user. The annual energy cost apportionment is presented by Figure 3.1-3. The electricity cost per MBtu at PBA is about six times higher than the cost of natural gas. The higher unit cost explains why electricity only accounted for nine percent of the annual energy use, but represented 36 percent of the annual energy cost.

**Figure 3.1-1**
**PBA Monthly Energy Consumption**
Electricity is for Substations A & B Only

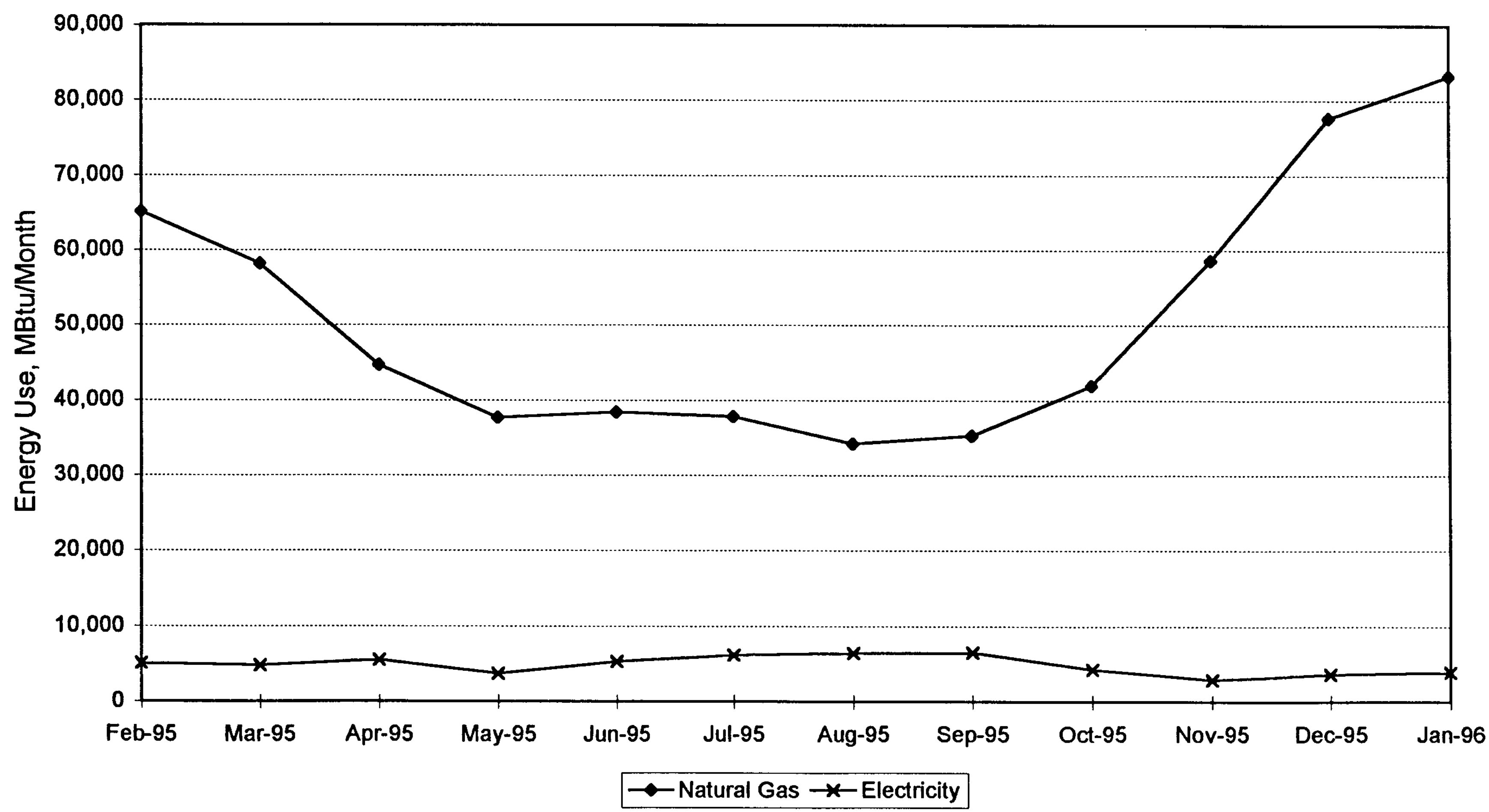


**Figure 3.1-2**

**PBA Annual Energy Use, 2/95 - 1/96**

Electricity for Substations A & B only

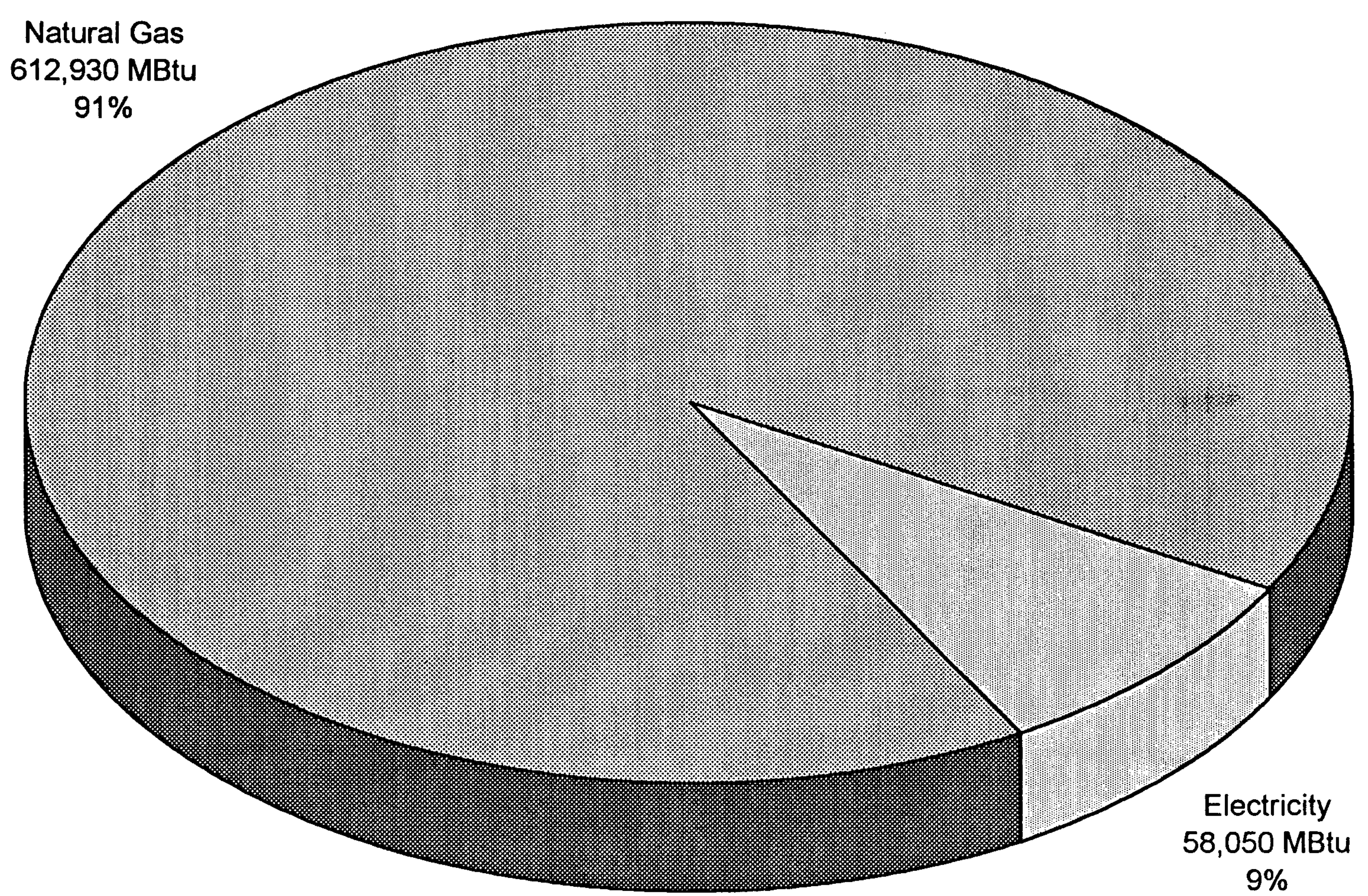
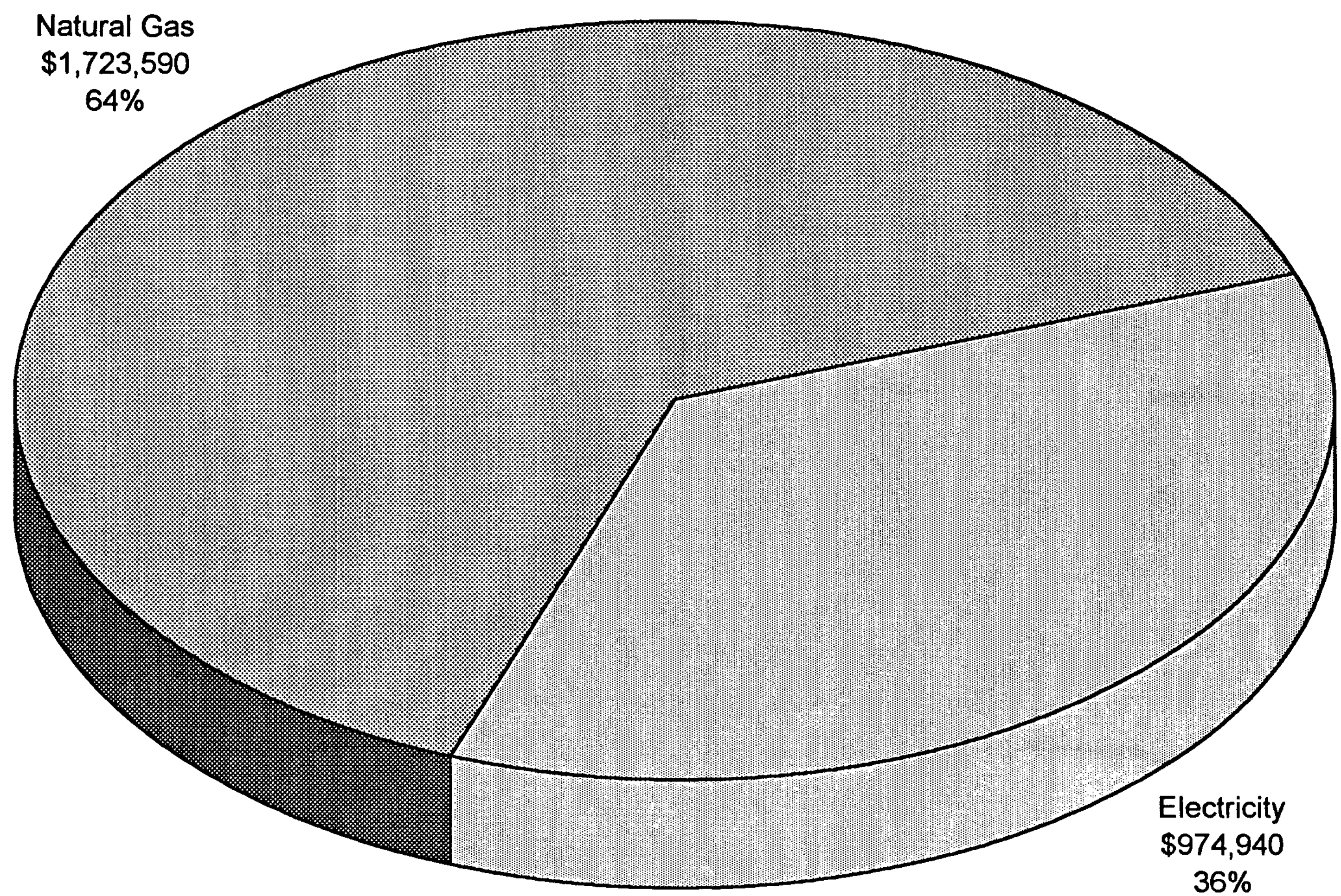


Figure 3.1-3

**PBA Annual Energy Cost, 2/95 - 1/96**

Electricity for Substations A & B only



## 3.2 ENERGY CONSUMPTION OF SYSTEMS STUDIED

The annual consumption and cost of natural gas and electricity used by various systems at PBA is presented in Table 3.2-1 and 3.2-2, respectively.

Table 3.2-1 Present Energy Consumption of Systems at PBA

| System | Natural Gas (MBtu/Yr) | Electricity (kWh/Yr) | Electricity (MBtu/Yr) |
|---|---|---|---|
| Boilers (Bldg. 32-060) | 163,392 | NA | NA |
| Boilers (Bldg. 33-060) | 125,255 | NA | NA |
| Boilers (Bldg. 34-140) | 203,467 | NA | NA |
| Steam System Leaks | 168,000 | NA | NA |
| Air Compressors | NA | 3,533,424 | 12,060 |
| Compressed Air Leaks | NA | 1,713,243 | 5,847 |
| WP Scrubber Fans | NA | 360,525 | 1,230 |
| Primary Water Pumps | NA | 372,403 | 1,271 |
| Filtered Water Pumps | NA | 216,459 | 739 |
| Incinerator Scrub. Fan | NA | 1,095,567 | 3,739 |

Table 3.2-2 Present Energy Cost of Systems at PBA

| System | Natural Gas ($/Yr) | Electricity ($/Yr) |
|---|---|---|
| Boilers (Bldg. 32-060) | $459,130 | NA |
| Boilers (Bldg. 33-060) | $351,670 | NA |
| Boilers (Bldg. 34-140) | $571,740 | NA |
| Steam System Leaks | $472,080 | NA |
| Air Compressors | NA | $202,490 |
| Compressed Air Leaks | NA | $98,180 |
| WP Scrubber Fans | NA | $20,650 |
| Primary Water Pumps | NA | $21,340 |
| Filtered Water Pumps | NA | $12,410 |
| Incinerator Scrub. Fan | NA | $62,780 |

The energy losses due to steam leaks within Production Areas 31, 32, 33 and 34 were estimated by performing a monthly natural gas balance for the entire Arsenal for calendar year 1995. Steam consumption at PBA includes process heating, process humidification and comfort heating. Steam losses include condensate leaks, thermal losses due to conduction and convection, system (boiler) efficiency and steam leaks. The following expression was derived for calculating natural gas use due to steam leaks in the production areas:

$$LEAKS_P = NG_B - IB_M - PE_P - CH_P - CL_P - TL_P$$

Definitions of the terms and results of the estimated natural gas balance achieved by utilizing this equation are shown in Table 3.2-3. The values of the terms in the equation were estimated by a series of calculations described in Volume I.

| Table 3.2-3 PBA Natural Gas Balance for 1995 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated Monthly Natural Gas Consumption (MBtu) | | | | | | | | | | | |
| Natural Gas Component | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1. Natural Gas Bills ($NG_B$) | 72,425 | 65,166 | 58,220 | 47,855 | 37,697 | 38,392 | 37,838 | 34,199 | 35,284 | 41,937 | 58,597 | 77,672 |
| 2. Bldgs w/ Meters ($IB_M$) | 9,187 | 10,282 | 7,633 | 5,274 | 2,505 | 3,814 | 5,233 | 5,277 | 4,505 | 6,079 | 6,715 | 9,367 |
| 3. Process Heat ($PE_P$) | 10,181 | 10,647 | 12,176 | 10,759 | 10,907 | 11,848 | 12,357 | 10,362 | 10,034 | 10,181 | 9,853 | 10,544 |
| 4. Comfort Heat ($CH_P$) | 35,117 | 27,788 | 20,787 | 6,854 | 2,517 | 271 | 73 | 137 | 1,322 | 7,812 | 18,317 | 30,387 |
| 5. Condensate Loss ($CL_P$) | 4,228 | 3,669 | 3,382 | 2,847 | 2,353 | 2,312 | 2,180 | 1,934 | 2,058 | 2,397 | 3,469 | 4,567 |
| 6. Conduction Loss ($TL_P$) | 4,564 | 4,080 | 4,392 | 4,116 | 4,138 | 3,890 | 3,971 | 3,984 | 3,947 | 4,234 | 4,266 | 4,530 |
| 7. Steam Leaks ($LEAKS_P$) | 9,148 | 8,700 | 9,849 | 18,005 | 15,277 | 16,257 | 14,024 | 12,505 | 13,417 | 11,234 | 15,977 | 18,278 |
| Steam Leaks (7) = (1) - (2) - (3) - (4) - (5) - (6) | | | | | | | | | | | | |

Results of the natural gas balance listed in Table 3.2-1 are presented graphically by Figures 3.2-1, 3.2-2 and 3.2-3. Figure 3.2-1 shows the results in bar graph format to illustrate how the values of each natural gas-consuming component add up to the total natural gas use. The bars at the bottom of this figure depict the estimated amount of natural gas wasted due to steam leaks.

Figure 3.2-2 is a line graph that shows how the values of the total natural gas use at PBA and all of the components vary on a monthly basis. The average estimated loss due to steam leaks during June, July and August is 14,260 MBtu per month. Based on this value, the economic analyses assume that the steam leaks remain constant at 14,000 MBtu per month throughout the year. Therefore, the total annual estimated energy loss due to steam leaks at the Arsenal is about 168,000 MBtu per year. Using $2.81 per MBtu as the average cost of natural gas, the cost of steam leaks at PBA is approximately $472,000 per year.

Figure 3.2-3 shows the annual natural gas energy distribution at PBA for 1995. Steam leaks in Areas 31, 32, 33, and 34 represent approximately 27 percent of the natural gas consumption and cost for 1995. Steam leaks are the single largest energy consumer at PBA.

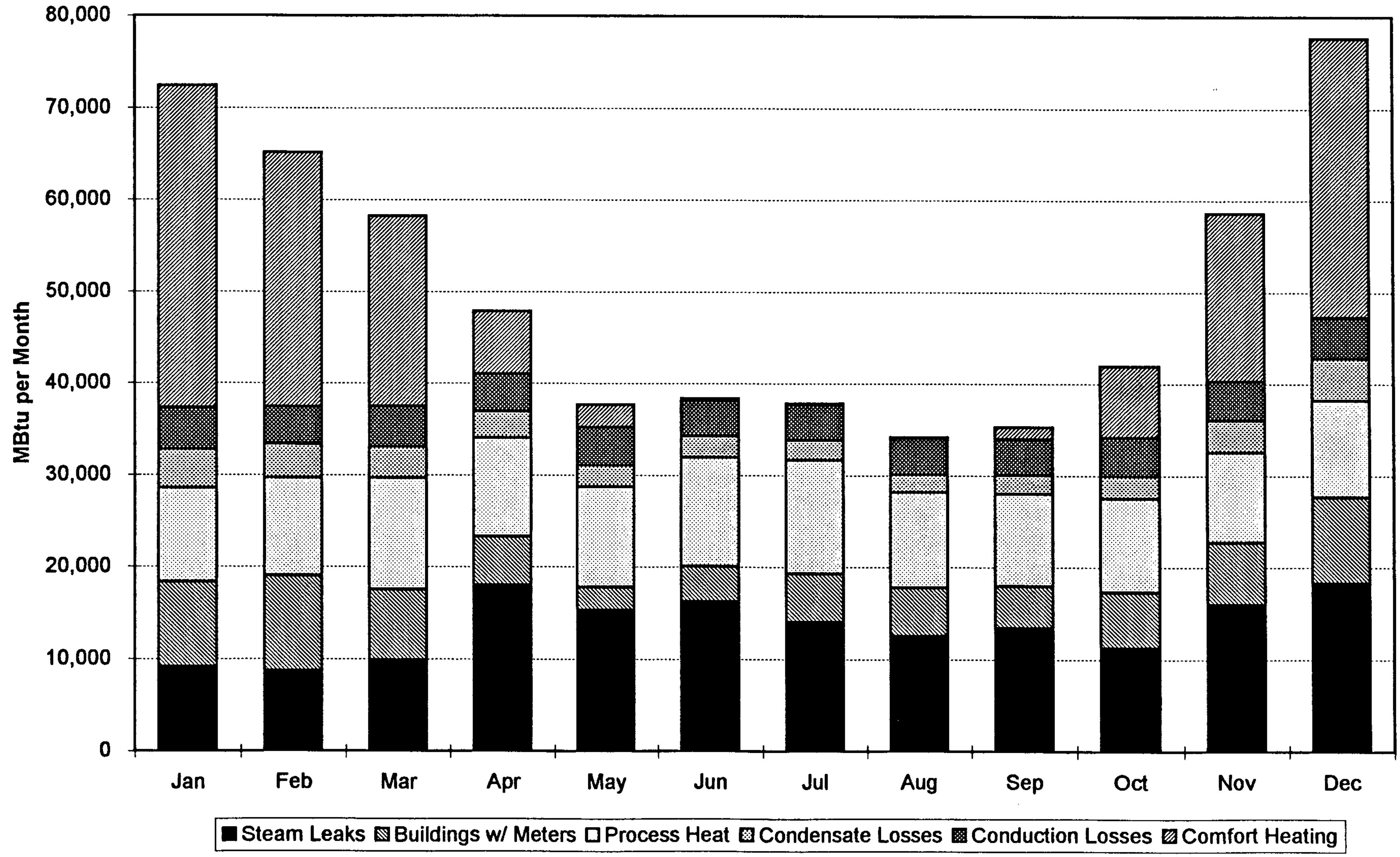
### 3.3 UTILITY RATES

The utility rates for electricity and natural gas that were used in the energy cost savings calculations and the economic analyses are presented in Table 3.5-1.

| Table 3.5-1. Pine Bluff Arsenal Utility Rates | | |
|---|---|---|
| Utility | Rate | Source |
| Natural Gas - Annual Average (1) | $2.81/MBtu | Natural Gas Bills |
| Electricity - Overall Average (1) | $0.057/kWh, $16.79/MBtu | Electric Bills |
| Energy - Annual Average | $0.029/kWh, $8.58/MBtu | Calc. from 12 months of data |
| Demand - Annual Average | $12.94/kW | Calc. from 12 months of data |

(1) Calculated from actual utility bills for the 12 month period from 2/95 through 1/96.

## Figure 3.2-1
## PBA Natural Gas Balance, 1995



## Figure 3.2-2
## PBA Natural Gas Balance, 1995

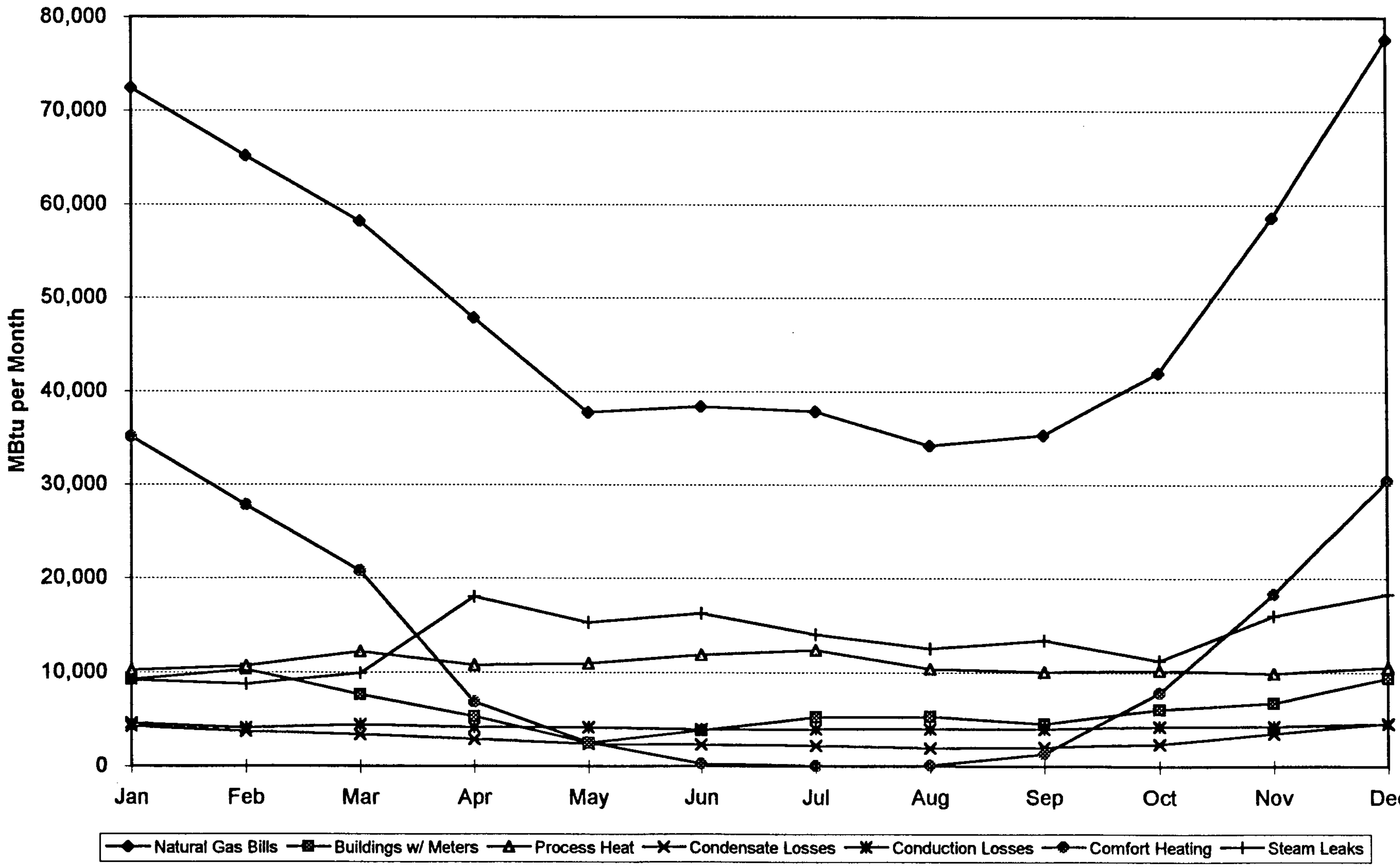
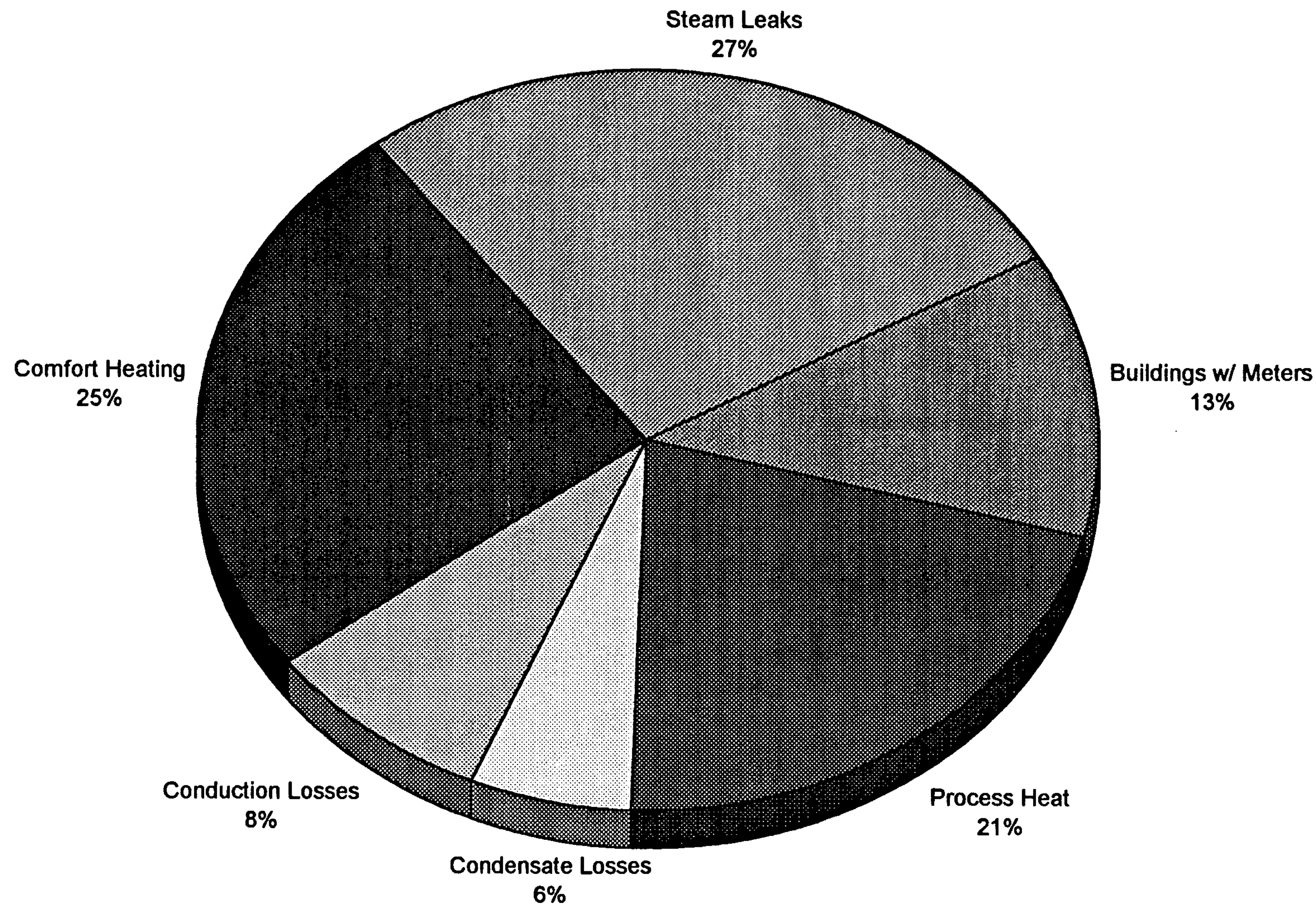


**Figure 3.2-3**
**PBA Estimated Annual Natural Gas Use, 1995**



## 4.0 REEVALUATED PROJECTS RESULTS

### 4.1 REEVALUATED PROJECTS

The Scope of Work for this study does not include the reevaluation of previously considered energy conservation projects.

# 5.0 ENERGY CONSERVATION ANALYSIS

## 5.1 ENERGY CONSERVATION OPPORTUNITIES (ECO's) INVESTIGATED

The purpose of this study is to conduct a detailed analysis of the boilers, air compressors and large electric motors in the production areas of PBA and develop projects to improve the efficiency of these systems. Table 5.1-1 lists all ECO's that were considered for this study. All of the ECO's that were eliminated from consideration prior to performing life cycle cost evaluations are indicated in this table along with the reasons for their elimination.

**Table 5.1-1 Summary of Energy Conservation Opportunities**

| ECO No. | Description of ECO | Evaluated | Comments |
|---|---|---|---|
| **Electrical Load Reduction** | | | |
| E1 | Replace synchronous motors for compressors. | No | Efficient synchronous motors not available. |
| E2 | Replace WP scrubber/exhaust motors. | Yes | |
| E3 | Replace primary water pump motors. | Yes | |
| E4 | Replace filtered water pump motors. | Yes | |
| E5 | Replace incinerator scrubber fan motor. | Yes | |
| E6 | Reduce Contracted Demand Limit | No | Electric rate does not have a demand limit. |
| **Steam Production and Distribution System** | | | |
| H1-A | Repair existing steam pipe and fittings. | Yes | |
| H1-B | Install new steam distribution piping system. | Yes | |
| H2-A | Bldg. 32-060 - Install new boilers. | Yes | |
| H2-B | Bldg. 32-060 - Improve efficiency of existing boilers. | Yes | |
| H2-C | Bldg. 32-060 - Install surplus boilers. | Yes | |
| H2-D | Bldg. 32-060 - Install economizers on surplus boilers. | Yes | |
| H3-A | Bldg. 33-060 - Install new boilers. | Yes | |
| H3-B | Bldg. 33-060 - Improve efficiency of existing boilers. | Yes | |
| H3-C | Bldg. 33-060 - Install economizers on existing boilers. | Yes | |
| H4-A | Bldg. 34-140 - Install new boilers. | Yes | |
| H4-B | Bldg. 34-140 - Improve efficiency of existing boilers. | Yes | |
| H4-C | Bldg. 34-140 - Install economizers on existing boilers. | Yes | |
| H5-A | Bldg. 42-960 - Install new boilers. | No | Existing boilers are operating efficiently. |
| H5-B | Bldg. 42-960 - Improve efficiency of existing boilers. | No | Existing boilers are operating efficiently. |
| H6-A | Bldg. 44-120 - Install new boiler. | No | Existing boiler is operating efficiently. |
| H6-B | Bldg. 44-120 - Improve efficiency of existing boiler. | No | Existing boiler is operating efficiently. |
| **Compressed Air System** | | | |
| C1-A | Replace existing compressors with surplus units. | No | Surplus compressors use more energy. |
| C1-B | Add surplus compressors to existing compressors. | No | Surplus compressors use more energy. |
| C2 | Replace exist. compressors with more efficient units. | No | Existing compressors are very efficient. |
| C3-A | Install dedicated compressors at the buildings. | Yes | |
| C3-B | Install new compressed air distribution piping system. | Yes | |
| C3-C | Repair existing compressed air pipe and fittings. | Yes | |

## 5.2 RESULTS OF ECO EVALUATIONS

The ECO evaluations included energy and labor savings calculations, cost estimates and economic analyses. Table 5.2-1 provides a summary of the results for all of the ECO evaluations. This table lists the evaluated ECO's in order of ECO Number.

**Table 5.2-1 Results of ECO Evaluations Performed July - September 1996**

| ECO No. | Total Project Cost $ | SIR | Simple Payback Years | N. Gas Savings MBtu/Yr | Electric Savings MBtu/Yr | Total Savings MBtu/Yr | N. Gas Savings $/Year | Electric Savings $/Year | O & M Savings $/Year | Total Savings $/Year |
|---|---|---|---|---|---|---|---|---|---|---|
| E2 | 117,540 | 0.36 | 41.4 | 0 | 168.9 | 169 | 0 | 2,840 | 0 | 2,840 |
| E3 | 26,700 | 1.16 | 13.0 | 0 | 122.6 | 123 | 0 | 2,060 | 0 | 2,060 |
| E4 | 8,320 | 2.09 | 7.2 | 0 | 68.8 | 69 | 0 | 1,160 | 0 | 1,160 |
| E5 | 21,230 | 1.56 | 9.7 | 0 | 131.0 | 131 | 0 | 2,200 | 0 | 2,200 |
| H1-A | 77,920 | 113 | 0.2 | 168,000 | 0 | 168,000 | 472,080 | 0 | 0 | 472,080 |
| H1-B | 5,647,000 | 1.55 | 12.0 | 168,000 | 0 | 168,000 | 472,080 | 0 | 0 | 472,080 |
| H2-A | 651,660 | 1.22 | 14.6 | 12,914 | 0 | 12,914 | 36,290 | 0 | 8,320 | 44,610 |
| H2-B | 7,140 | 47.2 | 0.4 | 6,457 | 0 | 6,457 | 18,140 | 0 | 0 | 18,140 |
| H2-C | 298,100 | 2.68 | 6.7 | 12,914 | 0 | 12,914 | 36,290 | 0 | 8,320 | 44,610 |
| H2-D | 85,810 | 3.27 | 5.7 | 5,381 | 0 | 5,381 | 15,120 | 0 | 0 | 15,120 |
| H3-A | 651,660 | 0.92 | 19.3 | 9,074 | 0 | 9,074 | 25,500 | 0 | 8,320 | 33,820 |
| H3-B | 7,140 | 30.2 | 0.6 | 4,125 | 0 | 4,125 | 11,590 | 0 | 0 | 11,590 |
| H3-C | 132,070 | 1.55 | 12.0 | 3,919 | 0 | 3,919 | 11,010 | 0 | 0 | 11,010 |
| H4-A | 846,850 | 1.30 | 13.9 | 18,761 | 0 | 18,761 | 52,720 | 0 | 8,320 | 61,040 |
| H4-B | 72,470 | 9.12 | 2.0 | 12,657 | 0 | 12,657 | 35,570 | 0 | 0 | 35,570 |
| H4-C | 195,550 | 1.65 | 11.3 | 6,164 | 0 | 6,164 | 17,320 | 0 | 0 | 17,320 |
| C3-A | 1,478,710 | 0.87 | 17.4 | 0 | 5060.9 | 5,061 | 0 | 84,970 | 0 | 84,970 |
| C3-B | 1,389,140 | 1.07 | 14.2 | 0 | 5847.3 | 5,847 | 0 | 98,180 | 0 | 98,180 |
| C3-C | 83,680 | 17.7 | 0.9 | 0 | 5847.3 | 5,847 | 0 | 98,180 | 0 | 98,180 |

## 5.3 RECOMMENDED ECO'S

ECO project funding criteria requires a savings to investment ratio (SIR) greater than 1.25 and a simple payback of less than 10 years. Based on this criteria, the results of the ECO evaluations were used to recommend projects for the heating system, compressed air system and some of the large electric motors at PBA. Table 5.3-1 lists all of the ECO's that meet the energy project funding criteria. The ECO's are listed in order of descending SIR along with the summary information from the ECO analyses.

**Table 5.3-1 Recommended ECO's**

| ECO No. | Total Project Cost $ | SIR | Simple Payback Years | N. Gas Savings MBtu/Yr | Electric Savings MBtu/Yr | Total Savings MBtu/Yr | N. Gas Savings $/Year | Electric Savings $/Year | O & M Savings $/Year | Total Savings $/Year |
|---|---|---|---|---|---|---|---|---|---|---|
| H1-A | 77,920 | 113 | 0.2 | 168,000 | 0 | 168,000 | 472,080 | 0 | 0 | 472,080 |
| H3-B | 7,140 | 30.2 | 0.6 | 4,125 | 0 | 4,125 | 11,590 | 0 | 0 | 11,590 |
| C3-C | 83,680 | 17.7 | 0.9 | 0 | 5847.3 | 5,847 | 0 | 98,180 | 0 | 98,180 |
| H4-B | 72,470 | 9.12 | 2.0 | 12,657 | 0 | 12,657 | 35,570 | 0 | 0 | 35,570 |
| H2-D | 85,810 | 3.27 | 5.7 | 5,381 | 0 | 5,381 | 15,120 | 0 | 0 | 15,120 |
| E4 | 8,320 | 2.09 | 7.2 | 0 | 68.8 | 69 | 0 | 1,160 | 0 | 1,160 |

These ECO's were recommended based on the results of the life cycle cost analyses. All of these ECO's have SIR's greater than 1.25 and simple paybacks of less than 10 years.

## 5.4 REJECTED ECO'S

Table 5.4-1 lists all of the ECO's that fail to meet the energy project funding criteria. The ECO's are listed order of ECO Number along with the summary information from the ECO analyses.

**Table 5.4-1 Rejected ECO's**

| ECO No. | Total Project Cost $ | SIR | Simple Payback Years | N. Gas Savings MBtu/Yr | Electric Savings MBtu/Yr | Total Savings MBtu/Yr | N. Gas Savings $/Year | Electric Savings $/Year | O & M Savings $/Year | Total Savings $/Year |
|---|---|---|---|---|---|---|---|---|---|---|
| E2 | 117,540 | 0.36 | 41.4 | 0 | 168.9 | 169 | 0 | 2,840 | 0 | 2,840 |
| E3 | 26,700 | 1.16 | 13.0 | 0 | 122.6 | 123 | 0 | 2,060 | 0 | 2,060 |
| E5 | 21,230 | 1.56 | 9.7 | 0 | 131.0 | 131 | 0 | 2,200 | 0 | 2,200 |
| H1-B | 5,647,000 | 1.55 | 12.0 | 168,000 | 0 | 168,000 | 472,080 | 0 | 0 | 472,080 |
| H2-A | 651,660 | 1.22 | 14.6 | 12,914 | 0 | 12,914 | 36,290 | 0 | 8,320 | 44,610 |
| H2-B | 7,140 | 47.2 | 0.4 | 6,457 | 0 | 6,457 | 18,140 | 0 | 0 | 18,140 |
| H2-C | 298,100 | 2.68 | 6.7 | 12,914 | 0 | 12,914 | 36,290 | 0 | 8,320 | 44,610 |
| H3-A | 651,660 | 0.92 | 19.3 | 9,074 | 0 | 9,074 | 25,500 | 0 | 8,320 | 33,820 |
| H3-C | 132,070 | 1.55 | 12.0 | 3,919 | 0 | 3,919 | 11,010 | 0 | 0 | 11,010 |
| H4-A | 846,850 | 1.30 | 13.9 | 18,761 | 0 | 18,761 | 52,720 | 0 | 8,320 | 61,040 |
| H4-C | 195,550 | 1.65 | 11.3 | 6,164 | 0 | 6,164 | 17,320 | 0 | 0 | 17,320 |
| C3-A | 1,478,710 | 0.87 | 17.4 | 0 | 5060.9 | 5,061 | 0 | 84,970 | 0 | 84,970 |
| C3-B | 1,389,140 | 1.07 | 14.2 | 0 | 5847.3 | 5,847 | 0 | 98,180 | 0 | 98,180 |

The SIR and simple payback period for ECO-E5, ECO-H2B and ECO-H2C meet the requirements for recommended projects, however, the equipment for all of these ECO's will be abandoned before the payback period.

### 5.5 ECIP PROJECTS DEVELOPED

To qualify for funding under the Energy Conservation Investment Program (ECIP) the construction cost of a project must be greater than or equal to $300,000. There are no individual ECO's that meet the ECIP requirements for construction cost.

### 5.6 NON-ECIP PROJECTS DEVELOPED

A list of all recommended ECO's that qualify as non-ECIP projects along with the summary information from the ECO analyses is presented in Table 5.6-1.

**Table 5.6-1 Non-ECIP Projects Developed (September 1996)**

| ECO No. | Total Project Cost $ | SIR | Simple Payback Years | N. Gas Savings MBtu/Yr | Electric Savings MBtu/Yr | Total Savings MBtu/Yr | N. Gas Savings $/Year | Electric Savings $/Year | O & M Savings $/Year | Total Savings $/Year |
|---|---|---|---|---|---|---|---|---|---|---|
| H1-A | 77,920 | 113 | 0.2 | 168,000 | 0 | 168,000 | 472,080 | 0 | 0 | 472,080 |
| H3-B | 7,140 | 30.2 | 0.6 | 4,125 | 0 | 4,125 | 11,590 | 0 | 0 | 11,590 |
| C3-C | 83,680 | 17.7 | 0.9 | 0 | 5847.3 | 5,847 | 0 | 98,180 | 0 | 98,180 |
| H4-B | 72,470 | 9.12 | 2.0 | 12,657 | 0 | 12,657 | 35,570 | 0 | 0 | 35,570 |
| H2-D | 85,810 | 3.27 | 5.7 | 5,381 | 0 | 5,381 | 15,120 | 0 | 0 | 15,120 |
| E4 | 8,320 | 2.09 | 7.2 | 0 | 68.8 | 69 | 0 | 1,160 | 0 | 1,160 |
| Totals | 335,340 | NA | 0.5 | 190,163 | 5916.1 | 196,079 | 534,360 | 99,340 | 0 | 633,700 |

Based on direction from PBA, documentation for funding under the Federal Energy Management Program (FEMP) was prepared for the following projects:

1. ECO-H1A; Repair existing steam distribution system pipe and fittings.
2. ECO-H2D; Install economizers on surplus boilers in Building 32-060 combined with ECO-H3B; Improve efficiency of existing boilers in Building 33-060.
3. ECO-C3C; Repair existing compressed air system pipe and fittings.
4. ECO-E4; Replace pump motors in Building 42-210 with energy efficient motors.

### 5.7 OPERATIONAL AND POLICY CHANGE RECOMMENDATIONS

**Boiler Operations**

1. Proper operation of the boilers at PBA has been neglected for some time. Communication and coordination between boiler operators and the production staff appears to be virtually non-existent. The steam consumers are unconcerned about their steam use because there is no penalty for squandering steam energy. No one appears to know exactly what system pressure should be maintained to meet the process equipment requirements. The entire system is currently being operated at 120 psig. Operation at 120 psig may not be necessary at all or it may only be required in order to service only one or two buildings. The lowest steam pressure that will produce successful Arsenal performance for winter and summer operations should be

determined immediately. All energy losses due to conduction and leaks can be reduced by operation at lower pressures.

2. Repair or replace the stack gas $O_2$ meters. All of the boilers in buildings 32-060, 33-060, and 34-060 are equipped with stack $O_2$ measuring devices that indicate on the control panels residual $O_2$ concentrations in the stack. Unfortunately, none of the instruments are working properly. There is no single reading more important to the efficient operation of the boilers than stack gas $O_2$. All $O_2$ instruments should be refurbished and maintained in good working order. Boiler operators should be encouraged to operate with about 1.7 percent residual $O_2$ in the stack. All of the fuel will not be burned when operating below 1.7 percent. In addition to wasting costly fuel, operating with excess accumulations of unburned fuel in the boiler can cause boiler explosions. When operating above 1.7 percent $O_2$, the boiler efficiency suffers and energy and money are wasted. Approximately $70,000 was wasted in 1995 because the boilers are operating with too much air. If the operator cannot operate the boilers at the proper $O_2$ level the cause should be addressed immediately. The cost of natural gas for operating these boilers at full load is approximately $1000 per day.

3. Repair or replace the fuel flow meters. All of the natural gas meters serving buildings 32-060, 33-060, and 34-060 are broken. These meters should be restored to proper service as soon as possible. Each individual boiler should also be equipped with a fuel flow meter. These meters are invaluable in diagnosing problems, cross-checking the steam flow meters and allowing equal share participation of all boilers.

4. Install steam flow meters on all buildings that utilize process steam. The costs of producing a particular product should be known. Process energy is certainly a component of the cost of each product. The Arsenal has about 70 natural gas meters that are read and recorded monthly. The fact that some energy is delivered in the form of steam does not negate the need to meter amount of energy consumed. Steam flow meters should be installed at every process building so that the proper energy costs may be readily attributed to the products produced. A method of billing or allocating energy costs should be determined and applied to all building occupants. This would provide some incentive for the Production Division to consolidate and conserve whenever possible.

<u>Steam Distribution</u>

1. Repair all steam leaks. Over $470,000 per year is being wasted due to about 128 steam leaks. These leaks are visible to everyone, especially during the winter. All visible or audible steam leaks, no matter how small, should be repaired as soon as possible. In addition to the steam

leaks in the distribution lines the leaks in the individual buildings and mechanical equipment rooms should be repaired. Steam leaks were noted in Buildings 34-140 and 32-720.

2. Turn off the steam supply to the WP area whenever possible. Personnel in charge of WP production should keep the boiler operators informed of their production plans. Steam should never be turned on to the WP area without notifying the boiler operators about eight hours in advance and again about 30 minutes prior to opening the valves. This common courtesy will allow the boiler operators time to anticipate the increase in steam demand by putting another boiler into service.

3. The steam heat tracing in the pollution abatement area, at the in-ground storage tanks, and in the above-ground storage area should be analyzed. These lines currently operate at system pressures of over 100 psig. Since the condensate from the steam heat tracing can not be brought back to the steam plant for safety reasons, then perhaps the lines could be operated at a substantially lower pressure. Steam at 10 psig has a temperature of about 240 degrees F.

<u>Compressed Air Distribution</u>

1. Repair all compressed air leaks. Approximately $85,000 per year is being wasted due to compressed air leaks. Many of these leaks are audible with out amplification, or a leak detector can be rented for about $200 per month. All audible compressed air leaks, no matter how small, should be repaired as soon as possible. The following compressed air leaks were noted during the survey of the steam distribution system;

   Leak from air line near Building 31-820.
   Valve from air line open at Avenue 321A and 322 Street.
   Air leak at pipe union next to Building S32-270.
   Valve from air line was fully open at Building 33-670.
   Leak from air line at Building 34-130.
   Two leaks in air line at Building 34-650.

<u>Electric Motors</u>

1. The procurement staff and the departments requesting new motors for PBA facilities should specify premium efficient motors. A very simple spreadsheet computer program could be set up to determine if the additional cost of purchasing a new premium efficient motor would provide an acceptable payback.

## 6.0 ENERGY AND COST SAVINGS

### 6.1 POTENTIAL ENERGY AND COST SAVINGS

Based on 1995 energy data, the energy use and costs before and after project implementation are shown in Table 6.1-1.

**Table 6.1-1 Effects of Implementing ECO's**

| | Energy Use Before ECO's (MBtu/Year) | Energy Use After ECO's (MBtu/Year) | Energy Cost Before ECO's ($/Year) | Energy Cost After ECO's ($/Year) | Percent Reduction |
|---|---|---|---|---|---|
| Natural Gas | 612,931 | 422,768 | $1,723,589 | $1,188,842 | 31% |
| Electricity | 58,052 | 52,136 | $974,939 | $875,584 | 10% |
| Total | 670,983 | 474,904 | $2,698,528 | $2,064,426 | 29% |

The sum of the energy savings for all of the recommended ECO's provide a total natural gas savings of 190,163 MBtu per year and a total electric savings of 5,916 MBtu per year. The total annual energy consumption will be reduced from 670,983 MBtu to 474,904 MBtu. The total annual energy cost will be reduced from $2,698,528 to $2,064,426. The result is a total savings of about 196,079 MBtu per year and $633,700 per year or 29 percent of the current energy use and cost at PBA.

Figures 6.1-1 and 6.1-2 compare the 1995 annual energy consumption and cost with the projected energy consumption and cost after the recommended ECO's are implemented. The natural gas energy consumption and cost are reduced by about 31 percent and the electric energy use and cost will be lowered by approximately 10 percent.

**Figure 6.1-1**
**PBA Annual Energy Use Before and After ECO's**
Electric Use is for Substations A & B Only

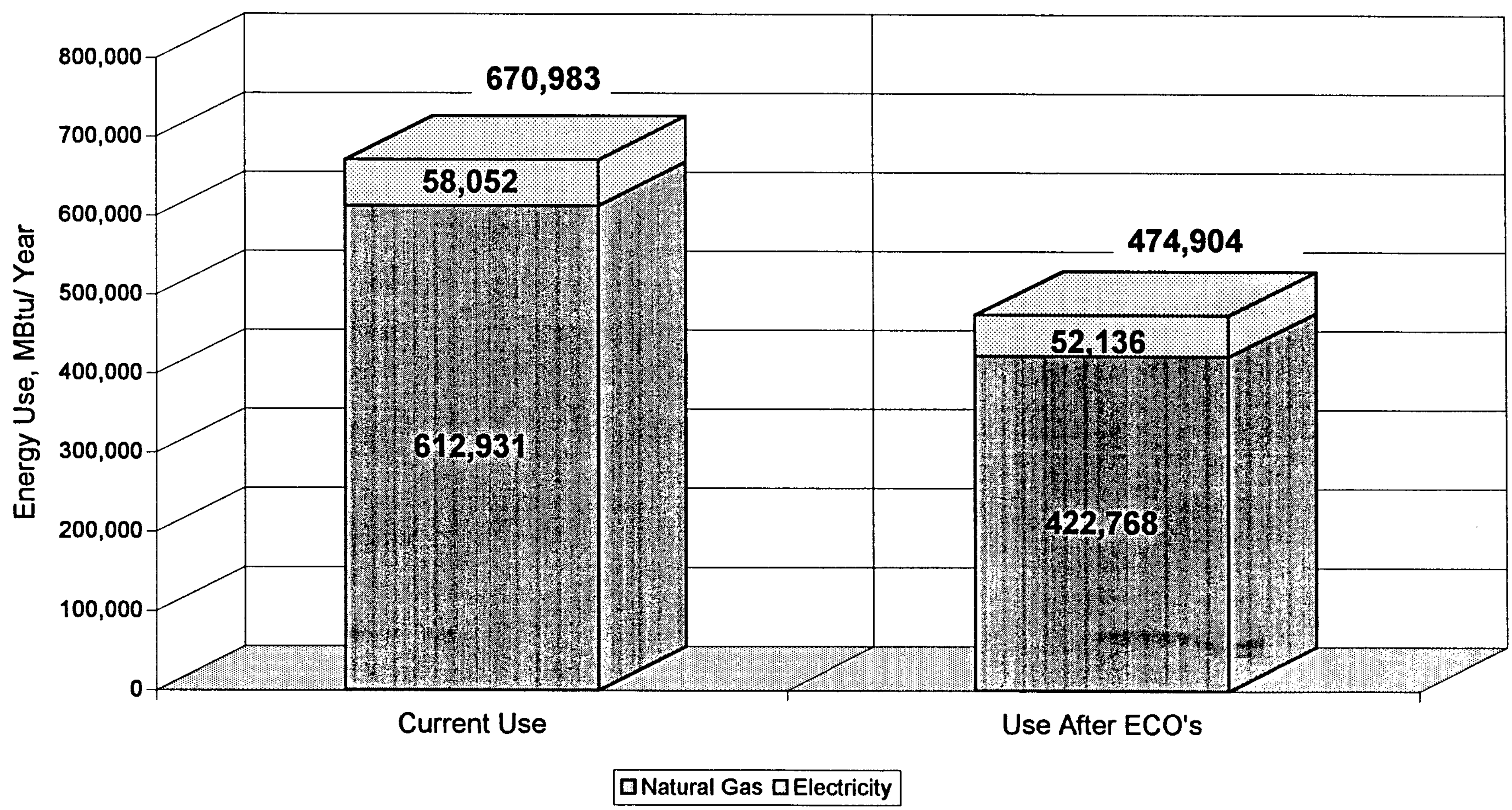


Figure 6.1-2

**PBA Annual Energy Cost Before and After ECO's**

Electricity Use is for Substations A & B Only